BIOGRAPHICAL SKETCH

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NAME: Hill-Maini, Vayu

eRA COMMONS USER NAME (credential, e.g., agency login): NA

POSITION TITLE: Assistant Professor, Department of Bioengineering, Stanford University, Stanford, California, United States

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
University of California, Berkeley, Berkeley, USA	Postdoctoral Fellow	08/2024	Bioengineering
University of California, Berkeley, Berkeley, USA	Miller Fellow	08/2023	Bioengineering
Harvard University, Cambridge, Massachusetts, USA	PhD	05/2020	Biochemistry
Carleton College, Northfield, Minnesota, USA	BA	05/2015	Chemistry & Biology

A. Personal Statement

My current research focus is on characterizing and engineering filamentous fungi for food and sustainability applications. I arrived at this focus through my extensive professional experience working as a chef and my doctoral training focused on elucidating metabolism of pharmaceutical drugs and dietary compounds in the human gut microbiota. My most recent work as a Miller Fellow and Postdoctoral Fellow working with Jay Keasling at UC Berkeley focused on building genetic tools and approaches to study and engineer fungal metabolism, which laid the foundation for my independent career. I recently established an interdisciplinary research program at Stanford University focused on developing and applying genetic tools to probe and manipulate fungal biochemistry and morphology. My research program integrates approaches from synthetic biology, gastronomy, and biochemistry, and while the research primarily focuses on urgent sustainability challenges, my work broadly aims to enhance our fundamental understanding of fungi and transform our ability to engineer these elusive organisms for diverse applications.

B. Positions, Scientific Appointments, and Honors

Positions
2024-present Assistant Professor, Stanford University, Department of Bioengineering, Stanford, California, United States

Other Experience and Professional Memberships
Memberships: Phi Beta Kappa, Sigma Xi

Honors
- **Price for best poster (post-doc), International Fungal Genetics Conference** (2022)
- **International Birnstiel Award for Doctoral Studies in Molecular Life Sciences,** Birnstiel Foundation (2020)
- **Miller Fellowship**, University of California Berkeley (2020)

- **Keystone Future of Science Scholarship** (2019)
- **HHMI Gilliam Fellowship for Advanced Study** (2017)
- **Peralta Award for Outstanding Candidacy Exam Proposal and Defense**, Department of Molecular and Cellular Biology, Harvard University (2017)
- **Ardis and Robert James Fellowship**, Harvard University (2017)
- **Public Service Grant**, COOP of Harvard and MIT (2017)
- **Student Initiative Award**, Harvard Integrated Life Sciences (2016, 2017, 2018)
- **Derek Bok Center Excellence in Teaching Award**, Harvard University (2017)
- **National Science Foundation Graduate Research Fellowship** (2015)
- **James Mill Pierce Fellowship**, Harvard University (2015)
- **Outstanding Scholar**, NorthStar STEM Alliance (2015)
- **Dean's list** (top 10% of class), Carleton College (2011-2015)
- **Franz Ezner Award for Excellence in Chemistry**, Carleton College (2015)
- **Second Century Student Award**, Carleton College (2015)
- **Social Justice Fellowship**, Carleton College (2015)
- **Barry M. Goldwater Scholarship** (2014)
- **Patricia V. Damon Scholarship for Excellence** (top 1% of junior class), Carleton College (2014)
- **Parent's Fund for Academic Excellence**, Carleton College (2014)
- **Class of 1966 Diversity of Achievement Scholarship**, Carleton College (2013, 2014)
- **Summer Science Fellowship**, Carleton College (2013, 2014)
- **Kolenkow-Reitz Fellowship for Research**, Carleton College (2012, 2013)
- **C.R.E.D.O Fellowship**, Carleton College (2012)
- **Student Leadership and Involvement Grant**, Carleton College (2012, 2014)

C. Contributions to Science

Microorganisms such as bacteria and fungi inhabit virtually every corner of the planet, including our own gastrointestinal tract and many of the foods that have sustained us through human history. Across these contexts, microbial metabolism profoundly shapes the surrounding environment and ecosystem. My research aims to enhance our fundamental understanding of these biochemical processes and create opportunities to manipulate microbial metabolism to improve human and planetary health.

1. Gut microbial metabolism:
I have tackled the fundamental challenge of identifying strains and enzymes responsible for widespread microbial metabolic pathways connected to human health, specifically in the human gut microbiota. At the start of my PhD, we knew *what microbes* lived in the gut, but we knew significantly less about *what* the microbes *were doing* at a *functional level*. My work elucidated specific microbial species and metabolic pathways involved in the breakdown of molecules that human ingest, including pharmaceutical drugs and dietary molecules. For example, I discovered microbial species and enzymes that degrade L-dopa, the main treatment for Parkinson's disease. I then developed a small molecule inhibitor that selectively and non-lethally inhibits the microbial degradation of this drug, increasing circulating drug levels in mice. This unveiled a previously unknown potential microbial drug target to enhance Parkinson's treatment. In another project, I uncovered a new class of enzymes (named catechol dehydroxylases) that degrades a group of molecules (polyphenols) present in foods such as coffee, tea, and tea and associated with human health. This work laid the foundation for multiple new postdoc and graduate student projects in the lab, and follow-up work in the lab has revealed that these catechol dehydroxylases utilize previously unknown chemistry to carry out their reactions and can directly influence how our diet is processed in our body. Overall, this work provided mechanistic insight into microbiota-host interactions while also unveiling new enzymes and pathways broadly relevant to microbial life on earth.

Example publications include:

- **Vayu Maini Rekdal**, P.N Bernadino, M.U Luescher, S. Kiamehr, P.J Turnbaugh, E.N Bess, E.P Balskus. A widely distributed enzyme class enables gut microbial metabolism of plant-and host-derived catechols. *eLife* **9**, e50845 (2020).
- **Vayu Maini Rekdal**, E.N Bess, J.E Bisanz, P.J Turnbaugh, E.P Balskus. Discovery and inhibition of an interspecies pathway for gut microbial Levodopa metabolism**.** *Science* **364**, eaau6323 (2019).
- N. Koppel, **Vayu Maini Rekdal**, E.P Balskus. Chemical transformation of xenobiotics by the human gut microbiota. *Science* **356**, eaag2770 (2017).

2. Fundamental and applied fungal biochemistry:
Switching fields at a Miller Fellow at UC Berkeley, I turned to the challenge of characterizing and engineering of filamentous fungi, a diverse and understudied group of organisms that includes molds and mushrooms. While fungi have massive potential for sustainably producing drugs, foods, materials, and chemicals, unlocking their full potential has been hindered by our poor understanding of their metabolism and a lack of genetic tools to engineer their biology. Addressing these gaps is the current focus of the recently established Hill-Maini lab at Stanford University.

In a recent project, I tackled the fundamental challenge of fungal enzyme discovery and characterization in the context sustainability. I specifically focused waste upcycling, e.g., the idea of using fungi to transform food waste into food to address sustainability and food security. I used multi-omics to characterize the fungal biotransformation of plant byproducts into a traditional meat alternative, oncom, in genetic and biochemical detail. These efforts identified strains of an edible fungus, *Neurospora intermedia,* that was domesticated by humans for converting waste into delicious and nutritious food, and revealed key genes and enzymes involved in waste breakdown. *N. intermedia* is safe to eat, has an appealing organoleptic profile, grows on diverse byproducts, and displays astonishing versatility across non-traditional substrates and product applications. To translate these findings into real-world impact, I worked with chefs from the 2 Michelin-star restaurant Alchemist in Copenhagen, Denmark, to establish that *N. intermedia* can be readily utilized to make diverse foods, including minimally processed plant-based milk that is positively rated in sensory trials. Spanning discovery and application, this work has enhanced our molecular understanding of fungal metabolism, shed light on human domestication of microbes for sustainable food production, and established *N. intermedia* as an edible, waste-specialized fungus with diverse applications in food production.

Example publications include:
- Maini Rekdal, V., Villalobos-Escobedo, J.M, Rodriguez-Valeron, N., Olaizola Garcia, M., Vásquez D.P., Rosales, A., Sörensen, P.M., Baidoo, EEK., Calheiros de Carvalho, A., Riley, R., Lipzen, A., He, G., Yan, M., Haridas, S., Daum, C., Yoshinaga, Y., Ng, V., Grigoriev, I., Munk, R., Wijaya, CH., Nuraida, L., Damayanti, I., Cruz-Morales, P., Keasling, J.D. Multi-omics analysis of a traditional fermented food reveals a byproduct-associated subpopulation of *Neurospora intermedia* for waste-to-food upcycling. bioRxiv: 2024.2007.2024.604980. doi: https://doi.org/10.1101/2024.07.24.604980. Accepted at *Nature Microbiology.*
- **Maini Rekdal V**, Rodriguez-Valeron N, Olaizola Garcia M, Prado Vásquez D, Sörensen P, Munk R, Keasling J. From lab to table: Expanding gastronomic possibilities with fermentation using the edible fungus *Neurospora intermedia*. International Journal of Gastronomy and Food Science. 2023 December; 34:100826-. doi: 10.1016/j.ijgfs.2023.100826.

3. Genetic engineering of filamentous fungi
In addition to understanding fundamental aspects of fungal metabolism and biochemistry with implications for planetary health, I have addressed the challenge of genetically engineering filamentous fungi, focusing on expanding uses and applications of edible fungi for sustainable foods. While genetic modification of filamentous fungi has promise for enhancing the nutritional value, sensory appeal, and scalability of fungal foods, genetic tools and demonstrated use cases for bioengineered food production by edible strains have been lacking. To address this gap, I recently developed a synthetic biology toolkit for *Aspergillus oryzae*, an edible fungus used in fermented foods, protein production, and meat alternatives. The toolkit includes an efficient and precise CRISPR-Cas9 method for gene integration, neutral loci, and new promoters, including bidirectional promoters and a synthetic expression system. Whereas similar toolkits are a standard feature of engineering yeasts such as *S. cerevisiae,* this is the first toolkit encompassing protocols and DNA parts for fast-targeted integration in

neutral loci and programmable gene expression in a filamentous fungus. We used these tools to elevate intracellular levels of the powerful antioxidant ergothioneine. Additionally, we engineered the eight-step pathway for the flavor-and color molecule heme in the edible biomass. The strain overproducing heme was red in color and was readily formulated into imitation meat patties with minimal processing. In addition to demonstrating the promise of synthetic biology for fungal food, this work presented a computational-experimental framework for building and evaluating synthetic biology tools in filamentous fungi, setting the stage for my current research program at Stanford University.

Example publications include:

- **Maini Rekdal V**, van der Luijt CRB, Chen Y, Kakumanu R, Baidoo EEK, Petzold CJ, Cruz-Morales P, Keasling JD. Edible mycelium bioengineered for enhanced nutritional value and sensory appeal using a modular synthetic biology toolkit. Nat Commun. 2024 Mar 14; 15(1):2099. doi: 10.1038/s41467-024-46314-8.
- Jahn LJ, **Maini Rekdal V**, Sommer MOA. Microbial foods for improving human and planetary health. Cell. 2023 Feb 2; 186(3):469-478. doi: 10.1016/j.cell.2022.12.002. Epub 2023 Jan 18. Review.

A Complete List of Published Work can be found at:
https://scholar.google.com/citations?user=uVG3NYgAAAAJ&hl=en